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Research Note

Studies on correlation and path analysis in exotic Genotypes of Italian millet [*Setaria italica* (L.) Beauv]

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Abstract
Thirty four exotic genotypes of Italian millet studied for correlation and path coefficient analysis during *kharif* and *rabi*. The investigation during *kharif* revealed positive significant correlation of days to 50% flowering, plant height, days to maturity, number of productive tillers per plant, ear length, ear weight and straw weight with yield per plant where as during *rabi* besides these characters flag leaf area and 1000 grain weight were also observed to influence yield. The association of protein content and calcium content with grain yield was in negative direction. The association of carotene with grain yield was negative in during *kharif* only. So simultaneous improvement of these traits along with grain yield may not be possible. The study indicated that direct selection based on the characters, number productive tillers per plant during *kharif* whereas in *rabi* ear weight and straw weight are effective as the association and direct effects were positive for these traits during both the seasons.

Key words:
Italian millet, *Seteria,* correlation, path analysis

Italian millet is also known as foxtail millet and German millet. It is an ancient cereal crop and is generally raised as rain fed crop in India. The grains are fed to cage birds. It is usually cooked whole or made into meal or into beer. It can also make useful hay or silage. In addition foxtail millet is consumed as stiff porridge called sargati, or as leavened bread known as roti, after the dehulled grain has been milled into flour. It is known for its drought tolerance and is an indispensable crop of vast rain fed areas in semi-arid regions in India. It is also grown in nutrient deficient soils and possesses tolerance to pests and diseases. The grain is a good source of protein and contains β-carotene. Italian millet grain possesses 12.3% protein, 4.7% fat, 60.6% carbohydrates and 3.2% ash. Foxtail millet with a short growing period is grown extensively in diverse agro- climatic regions for grain and fodder.

For improvement of complex traits like yield in any crop, indirect selection based on associated traits is the best breeding strategy. To identify the traits having positive influence on yield , this study was undertaken in Foxtail millet with 34 exotic genotypes.

The present investigation was undertaken at Agricultural College Farm, Bapatla, Andhra Pradesh with 34 Exotic genotypes of Italian millet [*Setaria italica* (L.) Beauv] procured from collections maintained at All India Co-ordinated Small Millets Improvement Project (AICSMIP), Bengaluru. The studies were carried out separately during two seasons of 2008-2009, namely k*harif* 2008 and r*abi* 2009. The genotypes were sown separately in randomized block design with four replications. Each genotype was sown in four rows of 5m length spaced at 25 X 10 cm apart. Data were collected on 10 randomly tagged competitive plants per genotype per replication for number of productive tillers per plant, plant height, flag leaf area, ear length, ear weight, straw weight/plant and grain yield/plant. However data on days to 50 %flowering, days to maturity, grain protein content, calcium content and grain β-carotene were recorded on plot basis. Phenotypic and genotypic correlations were worked out as per the procedures/ formulae by using the formulae suggested by Falconer (1964). Path coefficient analysis was used to calculate the direct and indirect contribution of various traits to yield. as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

In the present study genotypic correlations are higher than phenotypic correlation for all the characters during both seasons. This may be due to the relative stability of genotypes as majority of them were subjected to certain amount of selection (Johnson *et al.*, 1955).

The observed correlation between yield and its particular component is the net result of direct and indirect effects of the component characters through other yield attributes. The total correlation between grain yield and its component characters may sometimes be misleading since, it may be over or under estimate of its association with other characters. Hence, direct selection on correlated response basis may not be rewarding. The correlation coefficient needs to be split into direct and indirect effects, using path coefficient analysis for critical evaluation as many characters affect a given trait. Thus, the correlation and path analysis in combination, can give a better insight, into

cause and effect relationship between different pairs of characters.

The phenotypic and genotypic correlation coefficients between yield and yield components and inter- relationship among them were estimated in crops raised in *kharif* 2008 and *rabi* 2009 and presented in the Table 1 and 2 respectively. The study of exotic genotypes during kharif 2008 revealed positive significant correlation of days to 50% flowering, plant height, days to maturity, number of productive tillers per plant, ear length, ear weight and straw weight with grain yield per plant and improvement of seed yield may be possible if the above traits are considered in the selection programme.

In *rabi*,2009 the study revealed positive significant correlation of days to 50% flowering, plant height, days to maturity, number of productive tillers, flag leaf area, ear length, ear weight, straw weight and 1000 grain weight with grain yield per plant and improvement of seed yield may be possible if the above traits are considered in the selection programme. The association of protein and calcium content with grain yield is negative. The association of carotene with grain yield is negative during *kharif* only. Simultaneous improvement of these two traits is not possible. Similar results were earlier recorded by Dhagat *et al.* (1977), Reddy and Jhansi Lakshmi (1991), Sandhu *et al.* (1974),Gian Singh(1974), Nagarajan and Prasad (1980),Godawat and Gupta (1981), Singh and Nagaraja Rao (1989), Murugan and Nirmalakumari (2006) and Chidambaram and Palanisamy(1995).

The direct and indirect effects of different yield components on grain yield worked out through path analysis at phenotypic and genotypic levels are presented during *kharif* 2008 and *rabi* 2009 in table numbers 3, 4, 5 and 6. The study of exotic genotypes indicated that direct selection based on the characters, number productive tillers per plant during *kharif* where as in *rabi* ear weight and straw weight are effective as the association and direct effects were positive for these traits during both the seasons. Similar results were also noted by Nagarajan and Prasad (1980), Murugan and Nirmalakumari (2006), Reddy and Jhansi Lakshmi (1991) and Dhagat *et al*. (1977).

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References

Chidambaram, S and Palanisamy. 1995. Variability and correlation studies of dry matter with reference to selection criteria in foxtail millet (*Setaria italica*). *Madras Agric. J.,* **82**(1): 1-3

Dewey, D. R and Lu, K. H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.,* 51 **(9):** 515-518.

Dhagat, N. K., Goswami, U and Narsighani, G. 1977. Character correlation and selection indices in Italian millet. *Indian J. Agrl. Sci.,* **47**(12): 599-603.

Falconer, D. S. 1964. *An Introduction to Quantitative Genetics.* Second edition. Oliver and Boyd Ltd., Edinburgh,Pp: 312-324.

Gian Singh, 1974. Variability in kangni-3, Association between plant characters and discriminant function for varietal selection in four environments. *Indian J. Genet.,* **34**(2): 411-416.

Godawat, S. L and Gupta, S. C. 1981. Yield components and their implication to selection in foxtail millet. *Madras Agric. J.,* **68**(3):153-156.

Johnson, H. W., Robinson, H. F and Comstock, R. E. 1955. Estimates of genetic and environmental variability in soybean. *Agron. J.,* **47**: 314-318.

Murugan, R and Nirmalakumari, A. 2006. Genetic divergence in Italian millet [*Setaria italica*(L.) Beauv]. *Indian J. Genet.,* **66**(4):339-340.

Nagarajan, K and Prasad, M. N. 1980. Studies on genetic diversity in foxtail millet [*Setaria italica* (L.) Beauv] *Madras Agric. J.,* **67**(1): 28-38.

Reddy, C. D. R and Jhansi Lakshmi, K. 1991. Harvest index and yield parameters in foxtail millet [*Setaria italica* (L.) Beauv]. *Indian J. Genet.,* **51**(2):272-275.

Sandhu, T. S., Arora, B. S and Yashvir Singh. 1974. Interrelationships between yield and yield components in foxtail millet. *Indian J. Agrl. Sci.,* **44**(9):563-566.

Singh, K. D and Nagaraja Rao, M. 1989. Association analysis in foxtail millet [*Setaria italica* (L.) Beauv]. *J. Res. APAU.*, **XVII.** 68-69.

Wright, S. 1921. Correlation and causation. *J. Agrl. Res.*, **20**: 557-585.

Table 1 . Estimates of phenotypic and genotypic correlation coefficients among yield and yield components in Italian millet [*Setaria italica* (L.) Beauv] during *kharif* 2008

Character	Days to 50% flowering	Plant height(cm)	Days to maturity	No. of productive tillers	Flag leaf area(cm2)	Ear length(cm)	Ear weight(g)	Straw weight(g)	1000 grain weight(g)	Carotene (mg/100g)	crude protein(%)	calcium content (mg/100g)	Grain yield per plant (g)
Days to 50% flowering	-	-0.1507	0.3441**	0.2580*	-0.0565	0.0273	0.1885	0.1229	-0.0564	0.3618**	-0.0344	-0.0859	0.2444*
Plant height(cm)	-0.1515	-	0.0597	0.4965**	0.3251**	0.6106**	0.3752**	0.5962**	-0.0837	-0.2690*	-0.0166	0.2501*	0.5273**
Days to maturity	0.3840**	0.0629	-	0.5948**	-0.0529	-0.0956	0.4736**	0.5326**	0.2667*	0.0853	-0.2112	0.1209	0.5781**
No. of productive tillers	0.2873*	0.5262**	0.6191**	-	0.0373	0.4328**	0.8067**	0.8716**	0.1188	-0.0151	-0.108	-0.0324	0.9517**
Flag leaf area(cm2)	-0.0624	0.3254**	-0.0512	0.0398	-	0.2945*	-0.0884	-0.028	-0.1927	0.081	0.2707*	0.1942	0.0051
Ear length(cm)	0.0279	0.6277**	-0.0955	0.4556**	0.2974*	-	0.4760**	0.3061**	-0.1737	-0.0915	0.107	0.0688	0.4128**
Ear weight(g)	0.2037	0.3932**	0.5075**	0.8566**	-0.0987	0.4944**	-	0.7535**	0.0951	-0.075	-0.0673	-0.0099	0.8362**
Straw weight(g)	0.1377	0.6126**	0.5556**	0.9067**	-0.0307	0.3105**	0.7756**	-	0.0388	-0.2275**	-0.0771	-0.0667	0.9147**
1000 grain weight(g)	-0.0588	-0.0891	0.2795*	0.1277	-0.1928	-0.177	0.0943	0.0382	-	-0.0371	-0.3784**	-0.0592	0.0872
Carotene (mg/100g)	0.4202**	-0.2837*	0.0912	-0.0162	0.0892	-0.0939	-0.0722	-0.2404*	-0.0285	-	-0.1443	0.1654	-0.0586
crude protein(%)	-0.0389	-0.0157	-0.2194	-0.1137	0.2754*	0.1091	-0.0719	-0.0773	-0.3892**	-0.1499	-	0.1759	-0.0977
calcium content (mg/100g)	-0.0959	0.2563*	0.1244	-0.0319	0.1976	0.0696	-0.0118	-0.0672	-0.0625	0.1765	0.1774	-	-0.058
Grain yield per plant (g)	0.2787*	0.5451**	0.6093**	0.9956**	0.0009	0.4289**	0.8691**	0.9397**	0.0923	-0.0722	-0.0994	-0.0593	-

*and ** = significant at 5% and 1% level, respectively.
Values above diagonal indicate phenotypic correlation and values below diagonal indicate genotypic correlation coefficients, respectively

Table 2 . Estimates of phenotypic and genotypic correlation coefficients among yield and yield components in Italian millet [*Setaria italica* (L.) Beauv] during *rabi 2009*

Character	Days to 50 %flowering	Plant height (cm)	Days to maturity	No. of productive tillers	Flag leaf area (cm^2)	Ear length(cm)	Ear weight(cm)	Straw weight (g)	1000 grain weight (g)	Carotene (mg/100g)	crude protein (%)	Calcium content (mg/100g)	Grain yield per plant (g)
Days to 50 %flowering	-	0.2553*	0.8412**	0.3768**	0.0259	0.1391	0.2942*	0.5131**	0.0179	0.3810**	-0.2984*	0.0245	0.4370**
Plant height (cm)	0.2877*	-	0.2584*	0.4324**	0.4948**	0.5722**	0.5535**	0.5539**	0.3031**	0.0692	-0.1225	0.4509**	0.5422**
Days to maturity	0.8852**	0.2786*	-	0.2936*	-0.0358	0.1028	0.1894	0.4702**	-0.0156	0.3581**	-0.2516*	0.1667	0.3680**
No. of productive tillers	0.4033**	0.4490**	0.3175**	-	0.1205	0.3044**	0.3065**	0.5266**	0.4152**	-0.0143	-0.1929	-0.0048	0.5717**
Flag leaf area (cm^2)	0.027	0.5111**	-0.041	0.1229	-	0.6711**	0.4271**	0.3226**	0.0812	-0.0341	-0.014	0.3033**	0.2987**
Ear length (cm)	0.1571	0.5904**	0.1062	0.3111**	0.6827**	-	0.5186**	0.3753**	0.1999	0.0601	-0.154	0.3528**	0.3673**
Ear weight (cm)	0.3239**	0.5663**	0.2049*	0.3091**	0.4338**	0.5274**	-	0.7598**	0.4084**	0.1041	0.0573	0.2960*	0.7687**
Straw weight (g)	0.5607**	0.5684**	0.5111**	0.5313**	0.3255**	0.3804**	0.7666**	-	0.4441**	0.1596	-0.1317	0.2996*	0.8565**
1000 grain weight (g)	0.0252	0.3140**	-0.007	0.4307**	0.0836	0.2045*	0.4202**	0.4510**	-	-0.122	0.0043	0.0572	0.4547**
Carotene (mg/100g)	0.4274**	0.0677	0.4061**	-0.0161	-0.0348	0.0578	0.1089	0.1663	-0.1386	-	-0.1819	0.2334*	0.0288
crude protein(%)	-0.3282**	-0.1226	-0.2695**	-0.1944	-0.0132	-0.1569	0.0573	-0.1323	0.0063	-0.1887	-	0.0417	-0.1667
Calcium content (mg/100g)	0.0249	0.4606**	0.1792	-0.0035	0.3066**	0.3571**	0.2978*	0.3010**	0.0588	0.2430*	**0.0412**	-	0.1536
Grain yield per plant (g)	**0.4881****	**0.5669****	**0.4112****	**0.5888****	**0.3083****	**0.3774****	**0.7871****	**0.8785****	**0.4828****	**0.0315**	**-0.1696**	**0.158**	-

*and ** = significant at 5% and 1% level, respectively.

Values above diagonal indicate phenotypic correlation and values below diagonal indicate genotypic correlation coefficients, respectively

Table 3. Estimates of direct and indirect effects (phenotypic) of yield components on yield per plant in Italian millet [*Setaria italica* (L.) Beauv] during *kharif* 2008

Character	Days to 50 % flowering	Plant height (cm)	Days to maturity	No. of productive tillers	Flag leaf area (cm^2)	Ear length (cm)	Ear weight (g)	Straw weight (g)	1000 grain weight(g)	Carotene **(mg/100g)**	Crude protein (%)	Calcium content **(mg/100g)**
Days to 50 % flowering	**0.0264**	-0.004	0.0091	0.0068	-0.0015	0.0007	0.005	0.0032	-0.0015	0.0096	-0.0009	-0.0023
Plant height (cm)	-0.0105	**0.0697**	0.0042	0.0346	0.0227	0.0426	0.0262	0.0416	-0.0058	-0.0188	-0.0012	0.0174
Days to maturity	0.012	0.0021	**0.0348**	0.0207	-0.0018	-0.0033	0.0165	0.0185	0.0093	0.003	-0.0073	0.0042
No. of productive tillers	0.1244	0.2394	0.2868	**0.4822**	0.018	0.2087	0.389	0.4203	0.0573	-0.0073	-0.0521	-0.0156
Flag leaf area(cm^2)	0.0004	-0.0021	0.0003	-0.0002	**-0.0065**	-0.0019	0.0006	0.0002	0.0012	-0.0005	-0.0018	-0.0013
Ear length(cm)	-0.0001	-0.0021	0.0003	-0.0015	-0.001	**-0.0034**	-0.0016	-0.001	0.0006	0.0003	-0.0004	-0.0002
Ear weight(g)	0.0315	0.0627	0.0792	0.1349	-0.0148	0.0796	**0.1672**	0.126	0.0159	-0.0125	-0.0112	-0.0017
Straw weight(g)	0.0388	0.1881	0.168	0.275	-0.0088	0.0966	0.2377	**0.3155**	0.0122	-0.0718	-0.0243	-0.0211
1000 grain weight(g)	-0.0002	-0.0003	0.0011	0.0005	-0.0008	-0.0007	0.0004	0.0002	**0.0041**	-0.0002	-0.0016	-0.0002
Carotene **(mg/100g)**	0.0182	-0.0136	0.0043	-0.0008	0.0041	-0.0046	-0.0038	-0.0115	-0.0019	**0.0504**	-0.0073	0.0083
Crude protein (%)	-0.0007	-0.0003	-0.004	-0.002	0.0051	0.002	-0.0013	-0.0015	-0.0072	-0.0027	**0.019**	0.0033
Calcium content **(mg/100g)**	0.0042	-0.0123	-0.0059	0.0016	-0.0095	-0.0034	0.0005	0.0033	0.0029	-0.0081	-0.0086	**-0.049**
Correlation with Grain yield per plant(g)	0.2444*	0.5273**	0.5781**	0.9517**	0.0051	0.4128**	0.8362**	0.9147**	0.0872	-0.0586	-0.0977	**-0.058**

*and **= significant at 5% and 1% level, respectively; Residual effect = 0.2291; Bold and diagonal values indicate direct effects

Table 4. Estimates of direct and indirect effects (genotypic) of yield components on yield per plant in Italian millet [*Setaria italica* (L.) Beauv] during *kharif* 2008

Character	Days to 50 % flowering	Plant height (cm)	Days to maturity	No. of productive tillers	Flag leaf area(cm^2)	Ear length(cm)	Ear weight(g)	Straw weight(g)	1000 grain weight(g)	Carotene **(mg/100g)**	Crude protein(%)	Calcium content **(mg/100g)**
Days to 50 % flowering	**0.0243**	-0.0037	0.0093	0.007	-0.0015	0.0007	0.0049	0.0033	-0.0014	0.0102	-0.0009	-0.0023
Plant height (cm)	-0.0147	**0.0973**	0.0061	0.0512	0.0317	0.0611	0.0383	0.0596	-0.0087	-0.0276	-0.0015	0.0249
Days to maturity	-0.0008	-0.0001	**-0.0021**	-0.0013	0.0001	0.0002	-0.001	-0.0011	-0.0006	-0.0002	0.0005	-0.0003
No. of productive tillers	0.2492	0.4563	0.5369	**0.8671**	0.0345	0.395	0.7428	0.7862	0.1107	-0.014	-0.0986	-0.0276
Flag leaf area(cm^2)	0.0018	-0.0095	0.0015	-0.0012	**-0.0292**	-0.0087	0.0029	0.0009	0.0056	-0.0026	-0.008	-0.0058
Ear length(cm)	-0.0024	-0.0546	0.0083	-0.0397	-0.0259	**-0.0871**	-0.043	-0.027	0.0154	0.0082	-0.0095	-0.0061
Ear weight(g)	0.0202	0.0391	0.0504	0.0851	-0.0098	0.0491	**0.0994**	0.0771	0.0094	-0.0072	-0.0071	-0.0012
Straw weight(g)	0.0049	0.0218	0.0198	0.0323	-0.0011	0.0111	0.0276	**0.0356**	0.0014	-0.0086	-0.0028	-0.0024
1000 grain weight(g)	0.0021	0.0031	-0.0099	-0.0045	0.0068	0.0062	-0.0033	-0.0013	**-0.0353**	0.001	0.0137	0.0022
Carotene **(mg/100g)**	-0.009	0.0061	-0.002	0.0003	-0.0019	0.002	0.0015	0.0052	0.0006	**-0.0214**	0.0032	-0.0038
Crude protein(%)	-0.0007	-0.0003	-0.0042	-0.0022	0.0052	0.0021	-0.0014	-0.0015	-0.0074	-0.0028	**0.0189**	0.0034
Calcium content **(mg/100g)**	0.0039	-0.0104	-0.005	0.0013	-0.008	-0.0028	0.0005	0.0027	0.0025	-0.0071	-0.0072	**-0.0404**
Correlation with Grain yield per plant(g)	0.2787*	0.5451**	0.6093**	0.9956**	0.0009	0.4289**	0.8691**	0.9397**	0.0923	-0.0722	-0.0994	**-0.0593**

*and **= significant at 5% and 1% level, respectively Residual effect =SQRT (1- 1.0032); Bold and diagonal values indicate direct effects

Table 5. Estimates of direct and indirect effects (phenotypic) of yield components on yield per plant in Italian millet [*Setaria italica* (L.) Beauv] during *rabi* 2009

Character	Days to 50 % flowering	Plant height (cm)	Days to maturity	No. of productive tillers	Flag leaf area (cm^2)	Ear length (cm)	Ear weight (g)	Straw weight (g)	1000 grain weight (g)	Carotene **(mg/ 100g)**	Crude protein (%)	Calcium content **(mg/ 100g)**
Days to 50 % flowering	**-0.0602**	-0.0154	-0.0506	-0.0227	-0.0016	-0.0084	-0.0177	-0.0309	-0.0011	-0.0229	0.018	-0.0015
Plant height (cm)	0.0121	**0.0475**	0.0123	0.0205	0.0235	0.0272	0.0263	0.0263	0.0144	0.0033	-0.0058	0.0214
Days to maturity	0.0732	0.0225	**0.087**	0.0255	-0.0031	0.0089	0.0165	0.0409	-0.0014	0.0312	-0.0219	0.0145
No. of productive tillers	0.068	0.078	0.053	**0.1804**	0.0217	0.0549	0.0553	0.095	0.0749	-0.0026	-0.0348	-0.0009
Flag leaf area(cm^2)	0.0005	0.0095	-0.0007	0.0023	**0.0192**	0.0129	0.0082	0.0062	0.0016	-0.0007	-0.0003	0.0058
Ear length(cm)	-0.0144	-0.0592	-0.0106	-0.0315	-0.0694	**-0.1034**	-0.0536	-0.0388	-0.0207	-0.0062	0.0159	-0.0365
Ear weight(g)	0.1254	0.2359	0.0807	0.1306	0.182	0.221	**0.4261**	0.3238	0.174	0.0443	0.0244	0.1262
Straw weight(g)	0.2348	0.2535	0.2151	0.241	0.1476	0.1717	0.3477	**0.4576**	0.2032	0.073	-0.0603	0.1371
1000 grain weight(g)	0.0001	0.0013	-0.0001	0.0017	0.0003	0.0008	0.0017	0.0018	**0.0041**	-0.0005	0	0.0002
Carotene **(mg/100g)**	-0.0346	-0.0063	-0.0325	0.0013	0.0031	-0.0055	-0.0094	-0.0145	0.0111	**-0.0907**	0.0165	-0.0212
Crude protein(%)	0.0343	0.0141	0.0289	0.0221	0.0016	0.0177	-0.0066	0.0151	-0.0005	0.0209	**-0.1148**	-0.0048
Calcium content **(mg/100g)**	-0.0021	-0.0392	-0.0145	0.0004	-0.0263	-0.0307	-0.0257	-0.026	-0.005	-0.0203	-0.0036	**-0.0869**
Correlation with Grain yield per plant(g)	0.4370**	0.5422**	0.3680**	0.5717**	0.2987*	0.3673**	0.7687**	0.8565**	0.4547**	0.0288	-0.1667	**0.1536**

*and **= significant at 5% and 1% level, respectively Residual effect = 0.4161; Bold and diagonal values indicate direct effect

Table 6. Estimates of direct and indirect effects (genotypic) of yield components on yield per plant in Italian millet [*Setaria italica* (L.) Beauv] during *rabi* 2009

Character	Days to 50 % flowering	Plant height (cm)	Days to maturity	No. of productive tillers	Flag leaf area(cm^2)	Ear length(cm)	Ear weight(g)	Straw weight(g)	1000 grain weight(g)	Carotene **(mg/100g)**	crude protein(%)	calcium content **(mg/100g)**
Days to 50 % flowering	**-0.1277**	-0.0367	-0.1131	-0.0515	-0.0035	-0.0201	-0.0414	-0.0716	-0.0032	-0.0546	0.0419	-0.0032
Plant height (cm)	0.0132	**0.0457**	0.0127	0.0205	0.0234	0.027	0.0259	0.026	0.0144	0.0031	-0.0056	0.0211
Days to maturity	0.1494	0.047	**0.1687**	0.0536	-0.0069	0.0179	0.0346	0.0862	-0.0012	0.0685	-0.0455	0.0302
No. of productive tillers	0.0776	0.0864	0.0611	**0.1923**	0.0236	0.0598	0.0595	0.1022	0.0828	-0.0031	-0.0374	-0.0007
Flag leaf area(cm^2)	0.001	0.0195	-0.0016	0.0047	**0.0382**	0.0261	0.0166	0.0124	0.0032	-0.0013	-0.0005	0.0117
Ear length(cm)	-0.0198	-0.0745	-0.0134	-0.0392	-0.0861	**-0.1261**	-0.0665	-0.048	-0.0258	-0.0073	0.0198	-0.0451
Ear weight(g)	0.1499	0.2622	0.0948	0.1431	0.2008	0.2441	**0.4629**	0.3549	0.1945	0.0504	0.0265	0.1379
Straw weight(g)	0.2464	0.2498	0.2246	0.2335	0.143	0.1672	0.3369	**0.4395**	0.1982	0.0731	-0.0582	0.1323
1000 grain weight(g)	0.0003	0.0042	-0.0001	0.0057	0.0011	0.0027	0.0056	0.006	**0.0133**	-0.0018	0.0001	0.0008
Carotene **(mg/100g)**	-0.0406	-0.0064	-0.0386	0.0015	0.0033	-0.0055	-0.0103	-0.0158	0.0132	**-0.095**	0.0179	-0.0231
crude protein(%)	0.0409	0.0153	0.0336	0.0242	0.0016	0.0196	-0.0071	0.0165	-0.0008	0.0235	**-0.1246**	-0.0051
calcium content **(mg/100g)**	-0.0025	-0.0455	-0.0177	0.0003	-0.0303	-0.0353	-0.0294	-0.0297	-0.0058	-0.024	-0.0041	**-0.0988**
Correlation with Grain yield per plant(g)	0.4881**	0.5669**	0.4112**	0.5888**	0.3083**	0.3774**	0.7871**	0.8785**	0.4828**	0.0315	-0.1696	**0.158**

*and **= significant at 5% and 1% level, respectively Residual Effect = 0.3609; Bold and diagonal values indicate direct effects